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N.Z. DEPARTMENT OF SCIENTIFIC AND INDUSTRIAL RESEARCH.

BULLETIN No. 15.

PEACH CULTURE.

SPRAYING AND MANURIAL EXPERIMENTS IN THE NELSON DISTRICT.

BY

K. M. CURTIS, M.A., D.I.C., D.Sc.

AND

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In view of the great advantages which would be derived from a flourishing peach industry in the Nelson district, it was felt that no effort should be spared to ascertain whether brown rot could be controlled and the yield of fruit greatly improved by manurial treatment. In order to obtain information on these aspects of peach culture, experiments have been conducted by the authors in two typical orchards for a period of three years in one case and five years in the other. The orchards are located at Stoke and Umukuri, where the soils are well suited to peaches. The owners of these orchards—Mr. W. W. Anderson, of Umukuri, and Mr. T. C. C. Scott, of Stoke—have given invaluable assistance in the conduct of the experiments, and have been responsible for weighing the fruit from the different experimental blocks.

The experiments in connection with the control of brown rot are discussed in Part I, while those dealing with the manuring of peaches are dealt with in Part II.

PART I.—FOUR YEARS' CONTROL OF BROWN ROT IN NEW ZEALAND.

By K. M. Curtis.

The two chief fungus diseases affecting the peach in the Nelson district are brown rot and dieback, and as the former was particularly prevalent when the present experiments were about to be undertaken it was decided to confine attention to its control. In most cases, including that of the experimental orchard at Umukuri, peach orchards now remaining in the district form part of larger orchards under pip-fruit. In the circumstances it was felt desirable that the spray schedule followed should include only materials that the orchardist would normally use for the rest of the orchard, rather than introduce another fungicide requiring additional labour for its preparation. For this reason Bordeaux mixture and lime-sulphur, with the occasional addition of atomic sulphur, were the fungicides employed, instead of the admittedly more effective dry-mix lime-sulphur or the common precipitated sulphurs. Even better control than that secured in the experiments is therefore to be expected when the choice of spray materials is not restricted by the limitation imposed by the practical routine of a mixed orchard. The experiment is thus a practical demonstration over a number of years of the results that may reasonably be expected by any careful grower when the application of common fungicides, applied at suitable times with regard to both weather and phase of development of the fungus causing brown rot, is accompanied by those other, equally essential, practical steps that the nature of the fungus renders imperative.

Each year's experimental programme included recognition of the necessity for spraying, and, on occasion, for spraying repeatedly; but it also gave due prominence to general control precautions, which in the case of this disease demand particular attention, for in brown rot, more perhaps than in other diseases, spraying alone or indiscriminate spraying may be in part a waste of effort. The optimum result in yield of sound fruit requires that spraying should be directed by knowledge of the life-cycle of the fungus and of the times in the seasonal development of flower and fruit

at which the host plant is most susceptible to infection.* As reduction in the number or elimination of the sources of initial infection at the beginning of each season is the first practical step to be attempted in the control of a disease of this kind, special attention was paid each year to the three possible sources of infection—viz., the mummy remaining attached to the tree throughout the winter, the mummy (whole or broken) lying on or just beneath the surface of the ground at the foot of the tree, and the infected lateral. Of these sources the lateral and the mummy on the tree, both producing conidia, are together probably of far less importance than the ascospore-producing mummy on the ground, for there each mummy or portion may produce up to twenty apothecia, each of which gives off thousands of ascospores. As mummies are numerous under trees that had brown rot in quantity the previous season, the total output of ascospores from beneath a single tree may be enormous. Moreover as the ascospore on ejection is freely caught up by the breeze and carried to the tree, the total number of potential agents of infection threatening any one tree from this source alone is large.

In the experiment the danger of infection from this source was fully recognized, and special care was exercised each year to ensure that whole mummies, and as far as possible all portions of mummies, were removed from the ground by spring-time. In the first year of the experiment this necessitated a minute inspection of the ground before bud-movement, but in subsequent years the diseased fruit was gathered during the taking of the records at harvesting, and none remained to mummify on tree or ground. The danger of conidial infection from mummies on the tree and from diseased twigs in early spring was obviated by collection of the former and by careful pruning.† These precautions eliminated as far as possible the sources of initial infection at the beginning of the season, but in spite of this care some blossom infection occurred in certain years through infection by spores from outside sources. This necessitated a strict examination of the experimental trees during and just after the blossoming period, and a ruthless cutting-out of laterals bearing infected blossoms, whether they had healthy blossoms higher on them or not. In the first two years a

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* The blossoming and maturity periods of the peach are the times at which it is most susceptible to infection. Life-cycle of the fungus: In early spring fruit-mummies remaining on the tree from the previous season produce conidia (one kind of fungus spore) as also do twigs infected the previous season; mummies of a certain age that have fallen to the ground and lie buried in the soil produce stalked, flower-like growths (apothecia), the upper surface of which consists of upstanding tubes containing ascospores (another kind of spore). Conidia are splashed free by rain or blown free by wind; ascospores are violently ejected into the air, where they are carried by air-currents. Both kinds of spores on being borne to a susceptible part germinate when sufficient moisture is present and infect the blossom or fruit on which they rest. In about a week the fungus in the newly infected part gives rise to a crop of conidia; these repeat infection and conidial crops many times during one season, provided the host plant continues at a susceptible stage and sufficient rain occurs to promote germination. There are thus many crops of conidia in a season, but only one of ascospores. Twig infection occurs through the fungus in infected blossoms or fruits growing down within the spur into the twig, where it spreads and may eventually girdle the latter. Illustrations of the life-cycle of the fungus are given on Plate 4.

† The cutting-out of dead twigs while the leaves are on the tree and leafless twigs are easily detected is a more certain method of removing brown-rotted twigs than pruning when the trees are leafless. Prunings should be burnt and mummies burnt or buried to a depth of over a foot.

considerable number of blossom-bearing laterals had to be sacrificed, but as the yield of healthy fruit for these seasons indicates (page 9), the crops were heavy in spite of the free use of the secateurs. In the later seasons blossom infection was only slight, but the examination of all trees during the blossoming period was not relaxed.

The removal of the sources of infection before the season began and the cutting-out of laterals bearing diseased blossoms immediately at the close of the blossoming period constituted the two main general precautions of the experiment, and were considered as important as the applications of spray.

The experimental trees were in two plots, one comprising the varieties Kalamazoo (twelve trees), and Wiggins (thirty-six trees), and the other Mamie Ross alone (eighty-two trees). Apart from minor adjustments necessitated by orchard routine, the sprays given to all varieties were alike, and were applied on the same date, with the exception in certain seasons of the pre-maturity spray, which occasionally was applied later to the late-maturing variety Kalamazoo. As there is four weeks' difference between the times of maturation of the two sets of varieties, the pre-maturity spray of the Kalamazoo trees should have been postponed every year until closer to its picking-time, but this was not always practicable.

As already mentioned, the spray materials were those used for the other part of the orchard under pip-fruits. The schedule had definitely in view two objects—first, protection from infection at the two danger periods of the season, the pink to blossom stage and fruit-maturity; and, secondly, an elasticity in the time of application and number of the intermediate sprays in accordance with the climatic demands of the season. The schedule consisted of four basic sprays—viz. (1) Bordeaux mixture 5–4–50 at bud-movement (applied chiefly for leaf-curl); (2) L.S. 1–50 at the pink; (3) L.S. 1–120 at petal-fall; (4) L.S. 1–120 as the fruit approached maturity.

In addition to these basic sprays, the adjustable portion of the schedule included one, two, or three applications of L.S. 1–120 interpolated between petal-fall and pre-maturity, according to the requirements of the season, the larger number being given when there was much rain. Because of rain, also, basic sprays occasionally had to be repeated. Peach aphis is rife in the Umukuri district from spring on, and one or more applications of Black Leaf 40 were found necessary in most seasons for its control. An end-of-season spray, usually L.S. 1–50, applied after leaf-fall for general cleansing of the tree, had been included in the owner's schedule prior to the experiment and at his request was continued in that of the experiment. The following table gives the sprays, strength of spray, and dates of application for the four seasons. The contractions used are—B.M., Bordeaux mixture; L.S., lime-sulphur; B.L., Black Leaf 40; and AT, atomic sulphur. Unless otherwise stated, each spray was applied to all three varieties.

Season 1924–25.—The strength of the Bordeaux mixture at bud-movement this season was 6–5–50, but in all subsequent years it was reduced to 5–4–50. The season was wet, and rain largely interfered with the carrying-out of the intended schedule. The pink spray had to be repeated owing to a period of five consecutive days' rain toward the end of September. The first interpolated (*i.e.*, adjustable, non-basic) spray between the petal-fall and the pre-maturity sprays was given on the 12th November, and, owing to the wet season, it was intended to include another within that period, but the orchard was flooded from a neighbouring river and the second spray

Spray Schedule for the Four Seasons of the Experiment.

—	Season 1924–25.		Season 1925–26.		Season 1926–27.		Season 1927–28.	
	Date.	Spray.	Date.	Spray.	Date.	Spray.	Date.	Spray.
Bud-movement ..	Aug. 15	B.M. 6–5–50..	Aug. 18	B.M. 5–4–50..	Aug. 9..	B.M. 5–4–50 ..	Aug. 15 ..	B.M. 5–4–50
Pink	Sept. 1..	L.S. 1–50 ..	Aug. 29	L.S. 1–50 ..	Aug. 25	L.S. 1–50, Mamie Ross	Aug. 26–27	L.S. 1–50
					Aug. 31	L.S. 1–50, Wiggins and Kalamazoo.		
Repeat	Sept. 29	L.S. 1–120 ..	..	..	..	..	..	..
Petal-fall	Oct. 13	L.S. 1–120 ..	Oct. 7 ..	L.S. 1–120 ..	Oct. 4 ..	L.S. 1–120	Sept. 26 ..	L.S. 1–120
Repeat	..	..	..	..	Oct. 8 ..	L.S. 1–120, Mamie Ross	..	..
					Oct. 16	L.S. 1–120 Wiggins and Kalamazoo		
First interpolated ..	Nov. 12	L.S. 1–120 ..	Nov. 10	L.S. 1–120 + B.L. 1–1500	Nov. 10	L.S. 1–180 + B.L. 1–800	Oct. 17 ..	L.S. 1–120 + B.L. 1–800
Second interpolated	..	..	Nov. 27	L.S. 1–120 + B.L. 1–800	Nov. 24	L.S. 1–120 + B.L. 1–800	Nov. 17 ..	AT. 8–100 + B.L. 1–800
Pre-maturity ..	Dec. 24	L.S. 1–120 + B.L. 1–2000	Jan. 10	L.S. 1–120 ..	Dec. 23	L.S. 1–120, Mamie Ross	Dec. 30–31	L.S. 1–120
					Jan. 4..	L.S. 1–120, Wiggins and Kalamazoo		
Repeat	Jan. 3..	B.L. 1–1000..	..	..	Feb. 23	L.S. 1–180, Kalamazoo	Jan. 26	L.S. ¾-120, Kalamazoo.
(Winter)	May 20	L.S. 1–50 ..	June 15	L.S. 1–60 ..	May 1..	L.S. 1–100	..	..

could not be applied at the proper time; it was therefore given on the 24th December, the earliest day on which conditions permitted its application. It thus did duty for both the missing second interpolated and the pre-maturity sprays. For the early-maturing varieties, Wiggins and Mamie Ross, it was sufficiently late to serve the latter purpose fairly well, but it was too early to afford much protection to the Kalamazoo variety; nor was it found possible, owing to press of work consequent on the flood, to give a special pre-maturity spray at a more suitable time to the Kalamazoo variety, which was thus left unprotected at the critical maturity period. This was unfortunate, as the rainfall in December was heavy. Owing to infestation by peach-aphis, particularly on the Mamie Ross variety, two applications of Black Leaf 40 were found necessary during the season.

Season 1925–26.—In this season the schedule was followed without significant modification. The whole of the blossoming period, as fig. 2 shows, was wet, and, as it was succeeded by an October with much rain, two interpolated sprays were included between petal-fall and pre-maturity. Adverse climatic conditions occurred only during, and the month after, blossoming. Both November and December were fine, and, as the early general precautions had been observed and adequate sprays given, the danger of infection at maturity of the fruit was small. Aphis was again prevalent, but was kept in reasonable check by two applications of Black Leaf 40.

Season 1926–27.—The pink spray in this season was given at different dates for the two blocks owing to the Mamie Ross variety being more advanced. The early blossoming period was wet. Rain also fell immediately after the petal-fall application on the 4th October, and this spray was therefore repeated. The strength of the L.S. in the succeeding first interpolated spray was reduced to 1–180 because of the repetition of sprays at close intervals. Slight rain occurred at regular intervals throughout November, with heavy rain on three consecutive days in the last week in December. Aphis made its appearance early in November, and Black Leaf 40 was accordingly added to both interpolated sprays. The Kalamazoo variety matured late, and, as several days' rain fell shortly before its maturity, an additional spray was applied to this variety during the actual harvesting.

Season 1927–28.—This season was characterized by heavy rain at distant intervals, with the intervening periods unusually dry—a sequence facilitating brown rot control. There were three main rainy periods—at the end of August (shortly after the application of the pink spray), in mid-September (which the petal-fall spray coped with), and again in mid-November (covered by the second interpolated spray). The trees, therefore, had the protection of a spray shortly before or after all three rain-periods.

Brown Rot Record.

In taking the record at picking-time, that of the healthy fruit was determined in pounds, and that of the diseased in number of fruits, the percentage of disease then being computed by reckoning four fruits to the pound, an average suggested by the orchardist as representing a fair mean for the varieties.

Varietal Percentage of Brown Rot per Season.

—	Kalamazoo.		Wiggins.		Mamie Ross.	
	Brown Rot.	Total Yield.	Brown Rot.	Total Yield.	Brown Rot.	Total Yield.
	Per Cent.	lb.	Per Cent.	lb.	Per Cent.	lb.
1924–25..	5·4	148·5	1·3	245·5	0·34	297·5
1925–26..	0·7	1,142·0	0·49	1,027·0	0·13	1,362·0
1926–27..	0·55	2,219·5	0·069	1,094·0	0·097	3,614·0
1927–28..	0·27	2,553·0	0·26	2,330·0	0·09	4,185·0

It is to be noted that although the first season's percentage is fairly low, with the exception of one variety in one year there is a steady decrease to a very small percentage in all varieties each successive year of the experiment.

Average Seasonal Percentage, all Varieties together.—1924–25, 1·77 per cent. brown rot; 1925–26, 0·42 per cent.; 1926–27, 0·24 per cent.; 1927–28, 0·18 per cent. The percentage of brown rot over the period for the total crop, all varieties together, thus again shows a consistent reduction each year to a low final percentage.

Discussion.

Experiments in New Zealand on brown rot have been carried out in five seasons by the Horticulture Division of the Department of Agriculture —in two of the seasons, 1917–19, at Arataki (Hawke's Bay), and in five, 1917–19 and 1925–28, at Henderson (Auckland District). Careful pruning and removal of mummies were included in the routine in all instances, and in some treatments a lime-sulphur schedule followed a bud-movement Bordeaux, as at Umukuri. The earlier of these results are characterized by a wide range of infection per row, per variety, or per treatment, as the case might be, resulting in a comparatively high average percentage of affected fruits for the crop in each season. The Arataki mean seasonal percentages were: 17 and 7, with ranges 0–53 and 0–50; Henderson mean seasonal percentages were 14·4, 6·4, 14, 7·3, and 2·7, with ranges 1·7–75, 0·9–17, 2–50, 5–10, and 0·5–7.

As already stated, the averages in the Umukuri experiments were 1·7, 0·42, 0·24, and 0·18 per cent., with varietal ranges 0·34–5·4, 0·13–0·7, 0·07–0·55, and 0·09–0·27 per cent. The consistent securing at Umukuri of reasonable commercial control for four years in succession, through good seasons and bad, is not attributed to unusual suitability of spray materials, for the lime-sulphur used stood about fourth in the order of effectiveness of sprays on the market, being preceded by dry-mix lime-sulphur, atomic sulphur, Sulfo, and the combination lime-sulphur + atomic sulphur. Rainfall is of undoubted importance in furthering brown rot infection, yet Umukuri has a large rainfall, rendering control there additionally difficult. Two of the three peach varieties at Umukuri are highly susceptible to brown rot—one at the blossoming stage, and the other at fruit maturity. Natural resistance of the host was therefore not responsible for the control. Nor is there any question as to the presence of brown rot in quantity both in the experimental orchard before the experiment was undertaken and in orchards in

the vicinity during its progress. The application of sprays at the two critical periods, and the removal of mummies and diseased twigs, were recognized as essential in both the northern and Umukuri programmes, so no new precaution was introduced at Umukuri in consideration of these factors. But two other features remain to be considered, one as essential and the other as desirable. (1) Infected blossoms left on the tree lead to the infection of other blossoms on the same tree, on other trees of the same variety, and more especially on trees of later-flowering varieties. This increases the danger of infection on all the trees as the fruit ripens later in the season. Infected blossoms should therefore be cut out as soon as possible after their detection, preferably before the petal-fall spray is applied. This cutting-out is a necessity under any circumstances; it is an urgent necessity in districts where the spring rainfall is usually heavy, and it is more than urgent where the chief part of that rain normally falls during the blossoming period. It is to the observance of the cutting-out of infected blossoms, no less than the destruction of mummies, removal of infected twigs, and application of essential sprays that the success of the present experiment is chiefly attributed. (2) A factor of secondary importance in the success of the Umukuri experiment is the insertion in the schedule of the variable, interpolated sprays, whose number and time of application were determined by climatic conditions. These sprays were aimed at warding off infection by conidia from outside orchards. If the control in all orchards in a district were strict, the application of sprays after rain reasonably swift (*e.g.*, preferably with the orchards piped), and the number of peach varieties sufficiently small to admit of sprays being applied at the time that suits the variety, instead of the majority of varieties, it is felt that essential sprays could eventually be reduced to a bud-movement, a pink to blossom, a petal- (or husk-) fall, and a pre-maturity, and that the interpolated sprays of the present experiment would no longer be necessary. In the meantime in districts of heavy spring rainfall, such as Nelson and Auckland, one or more of these interpolated sprays cannot be omitted with impunity, nor should the time of application be decided solely by orchard convenience, but rather by the rainfall.

Responsibility for heavy infection of a crop is often laid at the door of susceptibility of the variety. Wide variation in susceptibility undoubtedly occurs; but often it is not strictly due to inability of germinating spores to effect entry and grow freely in the host, but to certain characteristics of the latter not of necessity immediately connected with its susceptible part. What is really a susceptible variety may, indeed, escape heavy infection and appear semiresistant. For example, early blossoming varieties often escape blossom infection, because of the paucity of spores in the air at the time the blossoms open. Similarly, early fruiting varieties have more opportunity of escaping infection than those whose maturity sets in later, after clouds of conidia from diseased fruit of other varieties have been liberated. Form of blossom, again, may aid or hinder infection, the wide-spreading, flat-petalled type, such as that of Mamie Ross, affording a better catchment area for spores than the small blossom of Kalamazoo, whose incurved petals arch over and partially shield the nectary (in the honey of which spore germination is swift) from spores settling from the air. Recognition of simple characteristics of structure or development such as these are not infrequently of service in guiding the orchardist when the cutting-out of diseased blossoms is in progress, the seasonal development is abnormal, or when pressure of work renders impossible the application of sprays at times to suit every variety.

The Climatic Factor in Relation to Incidence of Brown Rot.

It is now an accepted fact that crop-loss through brown rot takes place mainly at the blossoming and maturity phases, and that if sources of infection are present rainfall is the other chief factor determining the amount of loss at these periods.

The rainfall of the Umukuri district during the experiment is therefore of interest with reference to its bearing on the control of brown rot secured in the experiment. In fig. 1 is shown the daily rainfall for Motueka, five

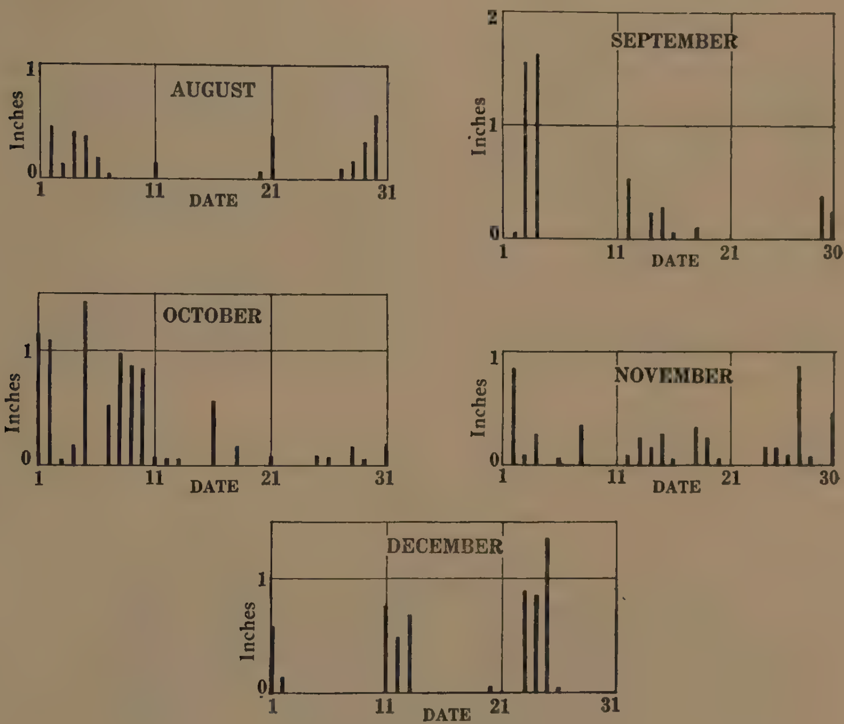


Fig. 1.—Season 1926.

miles from the experimental orchard, for August to December of 1926. This year was selected for illustration because its distribution of rain may be regarded as typical of the average season. The days of the month are given horizontally, and the rainfall vertically on the scale of 100 points to the inch. August had a moderate amount of rain, at fairly distant intervals. Early in September the rainfall was heavy; in the middle of this month there was a moderate fall,. and in the last week it set in again and continued with heavy falls until the second week in October. During the remainder of October rain occurred irregularly, and the falls were light. November in this year was an unusually wet month, but more usual conditions were reverted to in December, when the falls were grouped in several distinct periods, with a heavy fall in the last week. The regular rainfall in August permitted an unbroken development of the mummies; rain at intervals through September facilitated blossom infection, the liability

being particularly great when the full mass of blossoms was on the trees at the end of September and beginning of October. The rain in November shows the need in certain years for interpolated sprays, while December's heavy rain near the end of the month coincides with the ushering-in for early maturing varieties of the second danger period, the pre-maturity stage. A different type of year is illustrated in fig. 2, which gives the daily rainfall

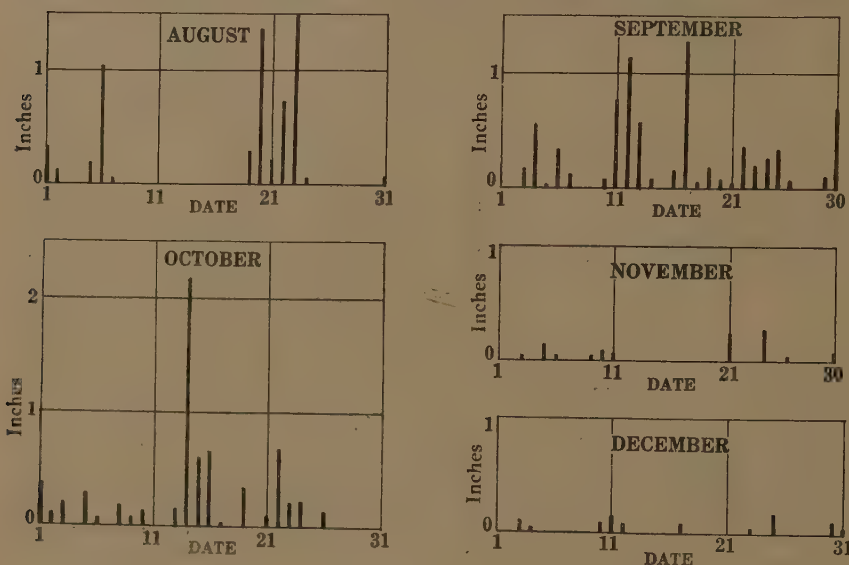


FIG. 2.—Season 1925.

for the same series of months in 1925. This season was characterized by an extremely wet spring and dry early summer. The August rainfall was more or less normal, but in September and October—that is, for the whole blossoming period—there was almost daily rain. The pre-maturity month was unusually fine, and the January rain fell chiefly in the middle of the month, so that some of the early-maturing varieties were harvested before it thoroughly set in. This season is therefore an excellent example of one in which much responsibility for the cleanliness of the crop depends on the thoroughness of the control of infection at the blossoming period. It was the second season of the experiment, and the final degree of control had not been attained. Nevertheless the amount of brown rot in the crop was only 0·42 per cent. of the total yield of fruit.

Passing from consideration of the local Umukuri conditions to the wider field of the chief peach-growing districts in New Zealand, it is of interest to compare their liability to loss through climate with that of Umukuri, and thence to deduce whether the orchardist in those districts who observes full precautions may expect control as effective as that secured in the present experiment. Blossoming may be taken on an average as beginning on the 1st September and ending the second week in October (disregarding early extremes in the Auckland district and late extremes in Otago). The month of August, in addition to including a small portion of the blossoming period, is of general importance in that its rainfall largely

influences the total quantity of apothecia produced by the mummies, and therefore exercises a direct control on the number of initial sources of infection at blossoming-time ; this number, generally speaking, is low in a dry and high in a wet spring. Thus the rainfall of both August and September is directly operative in influencing blossom infection. Similarly, that of the last week or two of December, as well as that of January, plays a part in furthering infection in the ripening fruit. The rainfall of the two pairs of two consecutive months in each season therefore largely predetermines the difficulty the orchardist will experience in combating the disease that year.

With a view to clarifying general knowledge of the climatic factors at work in the various peach-producing districts in the country, an examination of the statistics for rainfall and, so far as they are available, for humidity has been made for the four main districts involved.* Auckland was selected to represent its district ; Hastings, that of Hawke's Bay ; Roxburgh, the Otago peach area ; and Motueka, that of Umukuri. In the accompanying diagrams the height of the columns represents the amount of rain, on the scale of 1 in. to 100 points, for the two periods August–September (fig. 3) and December–January (fig. 4). For each of the periods four pairs of uprights are given, one pair for each season of the experiment. In fig. 3 the first of the pair is the August record (A.) and the second the September (S.) ; similarly, in fig. 4 the first of the pair is the December record (D.) and the second that of the following January (J.).

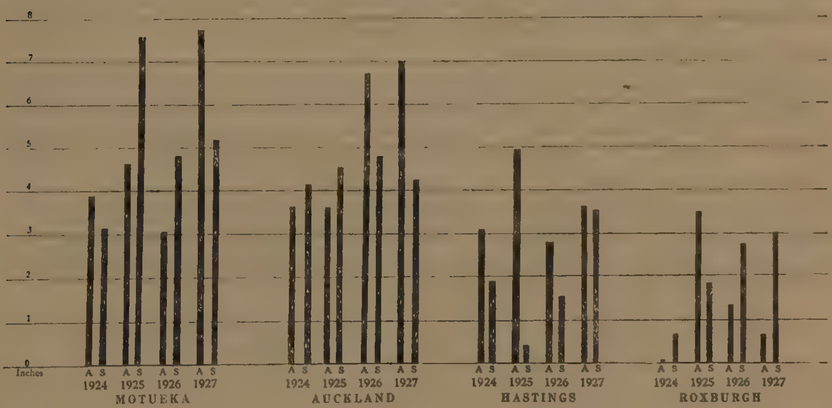


Fig. 3.—August–September Rainfall, 1924–27.

It will be seen (fig. 3) that Auckland and Motueka are alike in having heavy rainfall in the blossoming months ; that Hastings's rainfall for these months, though considerably less, is next in order ; and that Roxburgh's is far behind. The statistics for the total August and total September rainfall for the four centres throughout the four-year period, and the total number of days on which rain fell, are given in the following figures. As

* The writer has pleasure in acknowledging the courtesy of Dr. Kidson, Director, Meteorological Office, Wellington, in supplying statistics.

the season at Roxburgh is several weeks later than in the northern districts, its figures for the next month in each case are included for comparison.

August, 1924–27—			
Auckland	21·04 in.	on 84	days.
Motueka	19·57 ,,	55	,,
Hastings	14·56 ,,	62	,,
Roxburgh	5·53 ,,	30	,,
Roxburgh (September)	8·32 ,,	34	,,
September, 1924–27—			
Auckland	15·97 ,,	75	,,
Motueka	21·03 ,,	60	,,
Hastings	7·5 ,,	46	,,
Roxburgh	8·32 ,,	34	,,
Roxburgh (October)	9·08 ,,	37	,,

These figures show that while both Auckland and Motueka have heavy rain in August, Auckland has the heavier; and, in addition, that while both have a large number of wet days per month, Auckland's number exceeds that of Motueka by about seven per month. The main disadvantages of rain being distributed over many days are that it tends to shorten the duration of the protective action of sprays, and at the same time maintains an unbroken succession of germination in spores free at the time. In certain parts of the Auckland District, moreover, the blossoming of the early-flowering varieties begins in mid-August, and the month thus includes the liability not only of apothecial development but also, to a limited extent, of blossom infection. On the whole, therefore, while both Auckland and Motueka are subject to adverse conditions in August, Auckland is in the worse position of the two; while Hastings, in spite of its intermediate rainfall, has such a large number of wet days that the effect in stimulating apothecial development is probably little less than that of the two more rainy centres.

September introduces general danger of blossom infection throughout New Zealand. In rainfall for the month Motueka leads, but Auckland, which is not far behind, has its fall distributed over an average of four more days per month. The danger of infection resulting from rainfall is thus probably about equal in the two centres. Hastings and Roxburgh, on the other hand, have little rain in the blossoming month, and that on relatively few days, which facts taken in combination with the August (and, for Roxburgh, October) rainfall should mean only slight blossom infection in Roxburgh, with rather more in Hastings.

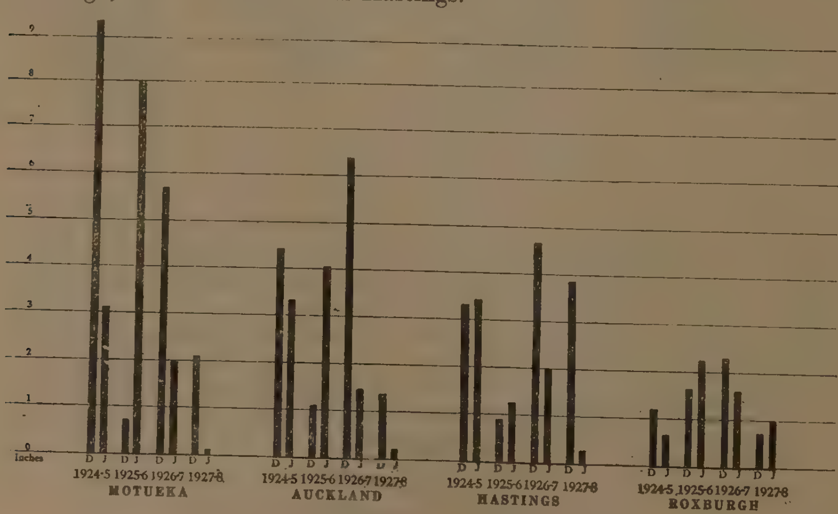


Fig. 4.—December–January Rainfall, 1924–28.

Figures for December and January (with the succeeding months for Roxburgh) corresponding to the diagram for these months (fig. 4) are as follows :—

December, 1924–27—			
Auckland	13·34 in.	on 57	days.
Motueka	17·75	,, 42	,,
Hastings	12·84	,, 42	,,
Roxburgh	6·09	,, 30	,,
Roxburgh (January)	5·66	,, 21	,,
January, 1925–28—			
Auckland	7·82	,, 34	,,
Motueka	13·17	,, 28	,,
Hastings	7·05	,, 42	,,
Roxburgh	5·66	,, 21	,,
Roxburgh (February)	8·12	,, 40	,,

The diagram and figures for the fruit-maturity period thus show that in the December rainfall Motueka again leads by a considerable margin, Auckland and Hastings are intermediate, and the Roxburgh record, as usual, is small. Again, however, Auckland's rain, though smaller in quantity, occurs on a greater number of days than Motueka's, while Hastings, with its characteristic light showers, has the same number of wet days as Motueka. Indeed, Roxburgh, with its small total fall, also shares the common characteristic of well-distributed rain in December and January. In the January records points of interest are the increase in the excess of rain at Motueka over that of all the other centres, and a distinct drop in the rainfall at the other centres. But for the tendency of the January rain at Motueka to occur as falls rather than as showers, the danger of fruit infection at Motueka at the maturity period would be excessive. Even as it is, the rain affords constant liability to infection. At fruit-maturity Roxburgh's liability continues low, though there is greater danger in February than in January.

Judging from the rainfall statistics alone, it may be said—

(1) That Auckland is liable to heavy apothecial development and heavy blossom infection ; that, provided both these dangers are coped with, it should not be liable to its present particularly heavy fruit infection.

(2) That Motueka is liable to heavy apothecial development, heavy blossom infection, and heavy fruit infection.

(3) That Hastings is liable to (moderately) heavy apothecial development, lighter blossom infection, and moderately heavy fruit infection.

(4) That Roxburgh is liable to light apothecial development, light blossom infection, and relatively light fruit infection.

The selection of arbitrary centres to represent a district necessarily excludes the consideration of range in the conditions operating throughout the district, but it at least affords a basis for comparison. From the facts elicited in the foregoing comparison it is evident that if the crop is to be rendered secure the Auckland and the Motueka orchardist must face his spring liabilities ; that the Hawke's Bay orchardist, if wise, will do the same ; while the Otago orchardist is not under the same obligation.

The preceding considerations have been based on rainfall only. Atmospheric humidity, no doubt, also plays a part in furthering or hindering

infection, though its effect is probably exercised more in maintaining spores in a non-desiccated, and therefore viable, condition than in actively promoting germination. Even this, however, when rain eventually renders germination possible, means that a larger number germinate than would have germinated if the previous humidity had been low. For high humidity alone to exercise a notable effect in maintaining spores in viable condition the interval between the falls of rain would need to be long. But in New Zealand high humidity is usually, though not invariably, correlated with frequent rain, and the effect of humidity is thus largely masked by the major effect of the rainfall. Statistics concerning atmospheric humidity in New Zealand are meagre. There are none for Roxburgh, and for Alexandra, the nearest place in the same district, humidity records were not taken before December, 1928. For that month Alexandra had a mean humidity of 49 per cent.; Hastings, of 70 per cent.; Nelson (not Motueka), of 71 per cent.; and Auckland, of 74 per cent.—*i.e.*, in this single instance the grading in the order of mean humidity for the four districts, with one exception, parallels that of the rainfall (Auckland 6 in.; Nelson, 8·67 in.; Hastings, 4·14 in.; Alexandra, 1·9 in.).

A comparison of the mean monthly humidity at Auckland and at Nelson (not Motueka) is possible for the full period of the experiment, viz.:—

Month.	1924.		1925.		1926.		1927.		1928.	
	Auckland.	Nelson.	Auckland.	Nelson.	Auckland.	Nelson.	Auckland.	Nelson.	Auckland.	Nelson.
	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.
January ..	..	..	76	78	75	78	75	73	68	63
August ..	80	79	81	78	79	76	80	81	..	..
September ..	77	81	78	75	78	73	84	83	..	..
December ..	78	74	76	67	77	71	70	80	...	..

From these figures it will be seen that with exceptions in occasional seasons the mean monthly humidity in Auckland is slightly higher than in Nelson. But the excess in mean humidity in any particular month at Auckland is not invariably correlated with excess in rainfall at Auckland for the month. For instance, in January of 1925 and 1926 Nelson had a higher rainfall than Auckland, and in both cases the mean monthly humidity at Nelson was also higher; but the reverse is the case in January, 1927, when the Nelson rainfall again was higher, but the mean humidity less, than in Auckland.

Summary.

(1) For four consecutive seasons, in some of which climatic conditions were bad, brown rot has been kept under control on three peach varieties in a commercial orchard at Umukuri. In the first season the amount of brown rot was reduced from the heavy general infection of previous years to 1·77 per cent. of the crop; by the fourth season it had been consistently reduced through 0·42 and 0·24 to 0·18 per cent. of the crop.

(2) The varietal percentages of brown rot in the Umukuri crop in yearly sequence from the 1924–25 season to that of 1927–28 were—Kalamazoo, 5·4, 0·7, 0·55, 0·27 per cent.; Wiggins, 1·3, 0·49, 0·07, 0·26 per cent.; Mamie Ross, 0·34, 0·13, 0·097, 0·09 per cent.

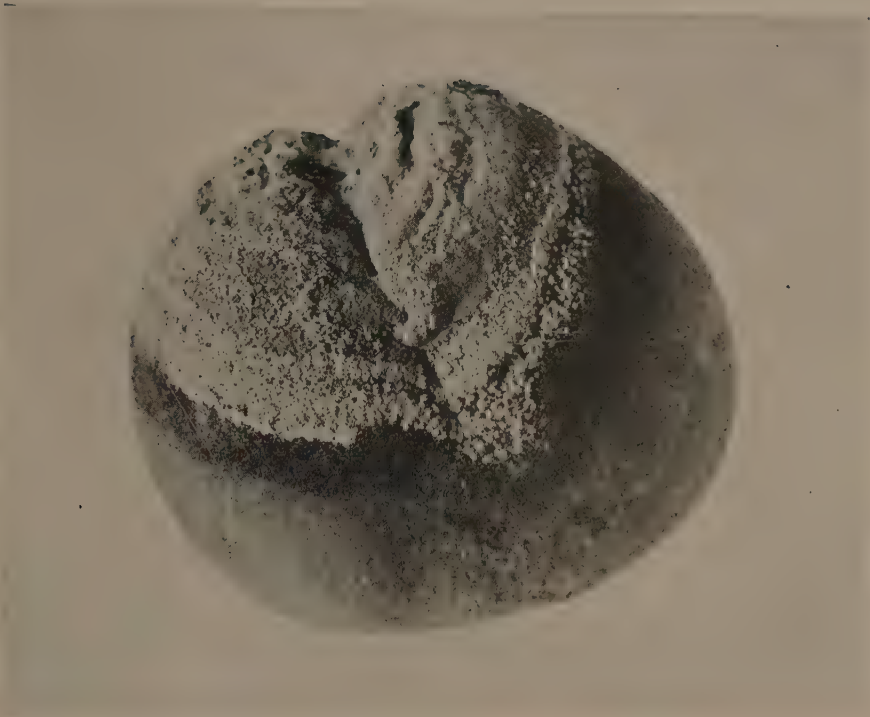


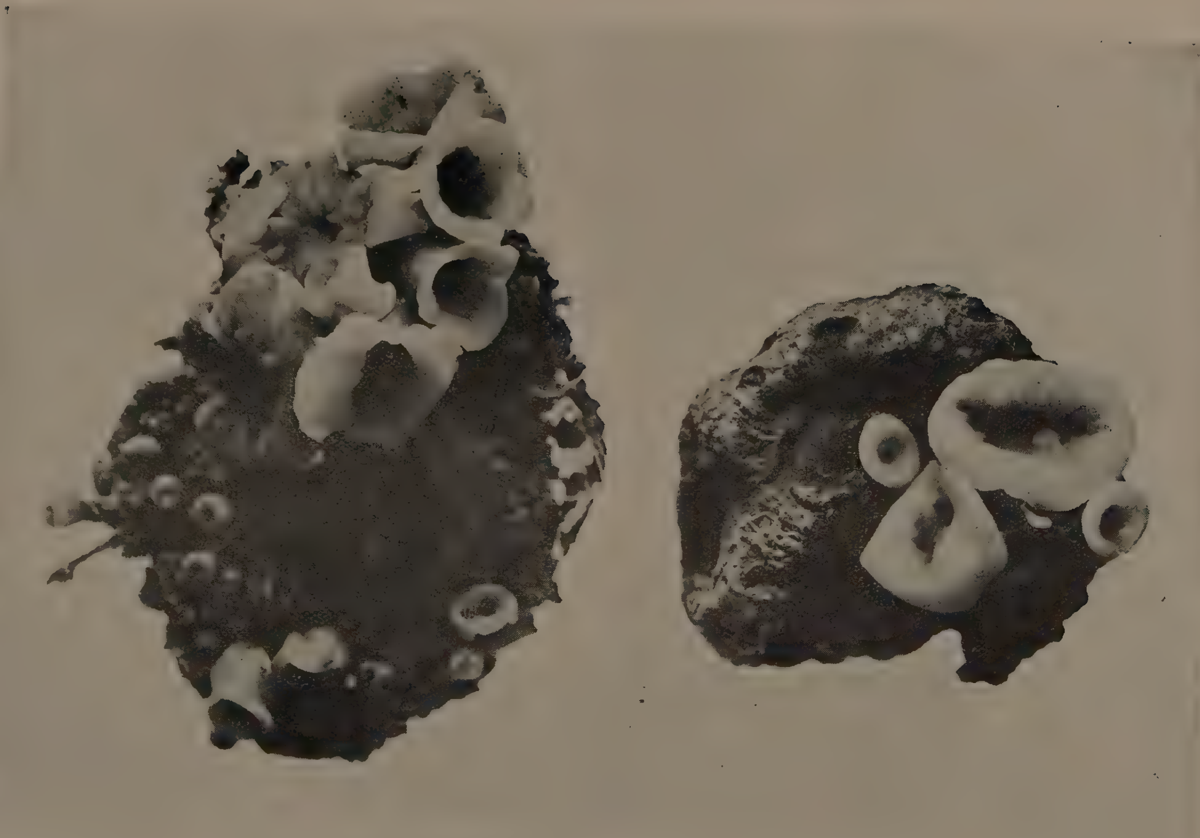
FIG. 1.—Peach bearing conidia of the brown rot fungus.

[*W. C. Davies, photos.*

FIG. 2.—Mummies in various stages of shrinkage during winter.

To face page 16.]

PLATE 2.



Apothecia developing on mummies partly buried in soil, early spring. [W. C. Davies, photo.

PLATE 3.

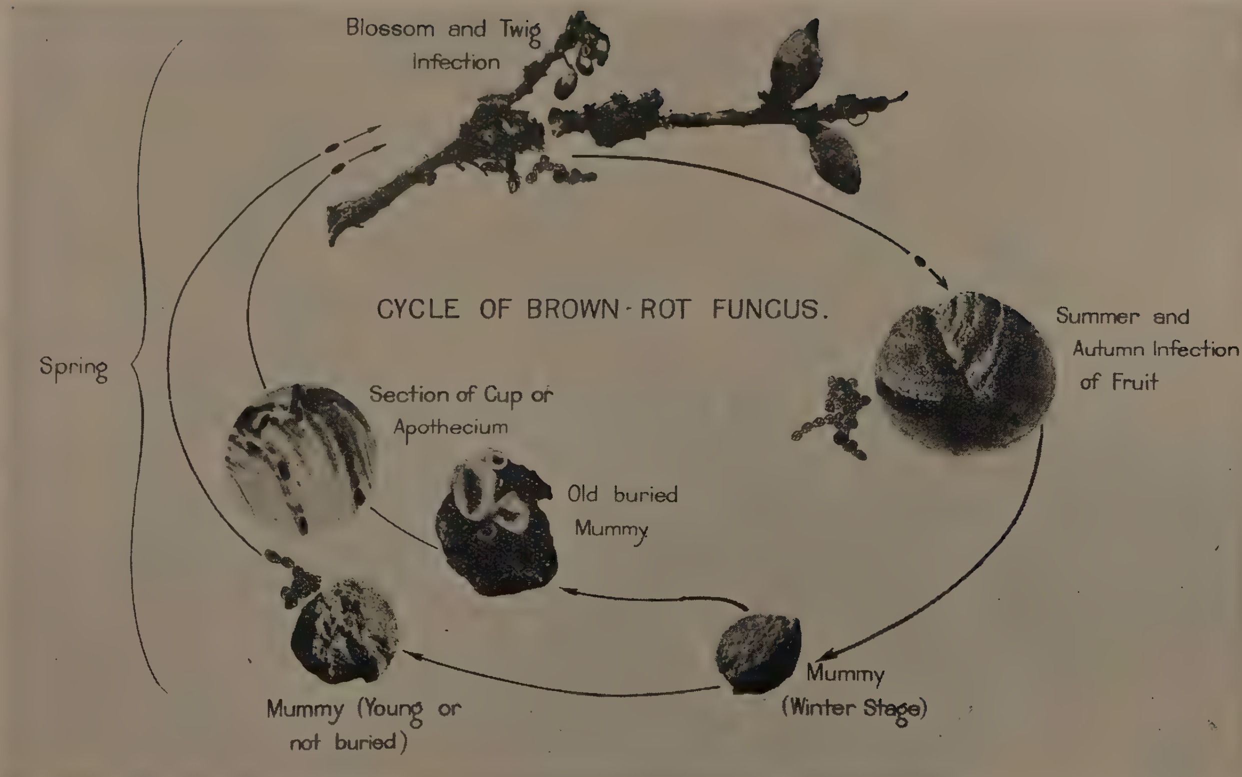
[W. C. Davies, photo.

FIG. 1.—Blossom infection, blossoms collapsed and bearing conidia.

[W. C. Davies, photo.

FIG. 2.—Twig infection caused by infection via the blossom-spur.

PLATE 4.



[W. C. Davies, photo.

Life-cycle of the brown rot fungus.

(3) The means whereby the control was secured comprised—

(*a*) The elimination as far as was possible of the sources of initial infection each spring—namely, removal and destruction of mummies from tree and ground, or, in seasons after the first, of diseased fruit before it could mummify, together with the cutting-out of diseased twigs.

(*b*) After blossoming-time the cutting-out of all laterals bearing diseased blossoms, thereby furthering the protection of the blossoms of later-flowering varieties and their laterals, and of all fruit.

(*c*) The application of adequate sprays, adequacy being considered to require a basic series of sprays (bud-movement, pink to blossom, petal-fall, and immediate pre-maturity), together with an adjustable interpolated series between petal-fall and pre-maturity. Weather and the amount of blossom infection that had occurred in both the experimental and the neighbouring orchards were the factors governing the number and time of application of the interpolated sprays; and weather was considered justification for the repetition of any of the basic sprays without necessarily eliminating the succeeding interpolated sprays.

(4) For the purpose of the experiment the sprays applied were those normally used in pip orchards—*i.e.*, Bordeaux mixture and lime sulphur. Even more complete control should be possible with dry-mix lime sulphur, the precipitated sulphurs, or a precipitated sulphur + lime sulphur.

(5) With Auckland, Hastings, Motueka, and Roxburgh considered as centres of their respective peach districts, rainfall and humidity statistics indicate that control may be expected to be almost equally difficult in Auckland and Motueka, to be somewhat less difficult in Hawke's Bay, and least difficult in Otago.

(6) The orchardist in every district in New Zealand should reduce blossom infection to the minimum, and when that minimum has occurred the Auckland and Nelson orchardist must, and the Hawke's Bay orchardist should, remove it by cutting out every lateral that bears a diseased blossom.

(7) If mummies and diseased twigs are destroyed, the details of (6) strictly observed, and a suitable spray schedule followed, most of the uncertainty now attending efforts for the protection of maturing fruit will be eliminated.

(8) Persistent care in the details enumerated, if universally observed,* together with the application of the pre-maturity spray at a time to suit the variety, not merely the majority of varieties, should remove the present necessity for the interpolated sprays in districts such as Auckland and Nelson.

(9) As it is well within the power of the normal orchardist in the Motueka district to secure control of brown rot, it is similarly within the power of the normal orchardist elsewhere in New Zealand to secure reasonably consistent control, whatever the district, whatever the season.

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* There must be no overlooking of the odd trees in the home orchard.

PART II.—PEACH MANURIAL EXPERIMENTS ON NELSON SOILS.

By T. Rigg.

I. Experiments at Stoke.

The orchard selected for the experiments was situated on a light loam containing 18–20 per cent. of small stones. The soil is typical of a large area used for peach and apple culture between Stoke and Richmond. It is underlaid by a mixture of small gravels, sand, and silt, which affords excellent drainage. The soil is moderately well supplied with available phosphate and potash, but it has an acid reaction and frequently shows a lime requirement of 2 tons of ground limestone per acre.

Prior to the commencement of the experiments, in 1924, little manurial treatment had been given. The trees showed a considerable amount of dieback. Growth and foliage development were rather poor. The yield of fruit was comparatively low, while considerable loss was sustained from brown-rot infection and the dropping of young peaches.

The block chosen for experiment was divided into treated and control areas, each of which contained trees of the Triumph, Kalamazoo, and Kia Ora varieties. As no lime treatment had been given for many years, an initial dressing of 2 tons of ground limestone per acre was applied. The following manurial treatment was given each year during the whole period of the experiments: In September a mixture consisting of 2 lb. superphosphate, 1 lb. sulphate of potash, and 1 lb. of ammonium sulphate per tree was broadcast and harrowed into the soil. In the latter part of November the trees received a top-dressing of 2 lb. of nitrate of soda per tree. A cover crop of blue lupins was sown without manure during January and was ploughed in during July in both years, 1925 and 1926.

During the summer following the first application of manure great improvement both in growth and foliage development took place on the treated block. The influence of manurial treatment on the yield of fruit, however, was negligible, the average yield on the treated blocks being 66½ lb., against 64½ lb. per tree on control areas.

During the two seasons which followed the trees on the treated blocks could easily be distinguished from those on the control areas by reason of their superior growth and foliage development. The following Table 1 shows the increase in yield resulting from the treatment in the 1925–26 and 1926–27 seasons.

Table 1.—Influence of Manurial Treatment on Yield.

Variety.	Control Block (No Treatment).			Treated Block.		
	1925–26.	1926–27.	Average for Two Seasons.	1925–26.	1926–27.	Average for Two Seasons.
	Pound per Tree.	Pound per Tree.	Pound per Tree.	Pound per Tree.	Pound per Tree.	Pound per Tree.
Triumph ..	32½	26	29¼	38	29½	33¾
Kalamazoo ..	10	62¼	36	38	78	58
Kia Ora ..	27	37	32	58¼	41	49½
Average, all varieties	23·2	41·7	32·4	43·7	49·5	47·1

Discussion of the Results.

It must be remarked that the Triumph trees on the control plot had an advantage over those on the treated plot in that they were on the northern side of the experimental block, facing the sun. In addition, the trees on the control area were superior in development to those on the treated plot. The difference in yield between the two plots is, therefore, not a fair measure of the full effect of manurial treatment on this variety. In the case of the Kalamazoo and Kia Ora varieties the trees on both treated and control areas were similarly situated in regard to light and competition for moisture and plant-food. The difference in yield between the treated and control blocks, therefore, fairly represents the effect of manurial treatment in the case of these two varieties.

A consideration of the data given in Table 1 shows that for the Kalamazoo and Kia Ora varieties an average annual increase of 20 lb. of fruit per tree has been effected by the manurial treatment. This represents an increase of 60 bushels per acre, which might be safely valued at £20. Allowing 5s. as an annual charge for ground limestone, the full cost of the manurial programme used in the experiment is under £6 per acre, giving a gross profit to the grower of £14 per acre.

II. Experiments at Umukuri.

The orchard selected for the experiments at Umukuri is located on a fine sandy soil, which is typical of much land in the Motueka district used for peach and small-fruit culture. The soil is underlaid by fine sand and sandy loam to a depth of at least 2 ft. 6 in., where gravels are frequently found. In texture the soil is ideally suited for peaches. It is well supplied with lime, and has a neutral reaction. It contains an abnormally large amount of available phosphate, but the supply of available potash is below normal.

Peach-trees frequently make slow growth during the first three years after planting, but then develop very well. Both growth of trees and yield of fruit are better than is the case with trees on the Stoke soil. Brown-rot infection and dieback of twigs and young branches have been the great difficulties attending peach-culture on this soil. Very hard pruning is frequently necessary to remove wood affected with dieback, greatly reducing thereby the fruiting-wood for the following season.

The experiments were conducted on two blocks of peach-trees. One of these was a block of young Mamie Ross trees which at the commencement of the experiment was just coming into bearing. This block was remarkably uniform in development, and was well suited for experimental work. The other block contained trees of the Kalamazoo and Wiggins variety. The Kalamazoo trees were all in full bearing, but the Wiggins trees were of different ages.

The two peach blocks were divided into three areas, which received the following treatments:—

Block I: No treatment.

Block II: Complete fertilizer, consisting of 2 lb. superphosphate, 2 lb. sulphate of potash, $\frac{1}{2}$ lb. sulphate of ammonia, and $\frac{1}{2}$ lb. dried blood per tree. This mixture was broadcast around the trees in September and harrowed well into the soil. In November the trees in this block received a dressing of 1 lb. nitrate of soda per tree.

Block III: Nitrogenous fertilizer only. The trees in this block received a mixture of 1 lb. of sulphate of ammonia and 1 lb. of dried blood per tree in September. In November a top-dressing of 1 lb. of nitrate of soda per tree was applied.

The experiments were continued over a period of five years, during which a careful record of fruit yields was made. The yield of fruit on the different blocks is shown in the following Tables 2 and 3.

Table 2.—Influence of Manurial Treatment on Mamie Ross Peaches.

Season.	Block I: Untreated.	Block II: Complete Fertilizer.	Block III: Nitrogenous Fertilizer.
	Pound per Tree.	Pound per Tree.	Pound per Tree.
1924–25	7·8	8·5	8·5
1925–26	32·0	41·5	44·0
1926–27	86·5	91·5	142·5
1927–28	88·7	161·7	122·0
1928–29	148·6	143·3	185·0
Total for five years	363·6	446·5	502·0
Yield during last three seasons ..	323·8	396·5	449·5
Average annual yield in last three seasons	107·9	132·2	149·8

NOTE.—Each block contained at least eleven trees.

Table 3.—Influence of Manurial Treatment on Kalamazoo and Wiggins Varieties.

Season.	Block I: Untreated.	Block II: Complete Fertilizer.	Block III: Nitrogenous Fertilizer.
	Pound per Tree.	Pound per Tree.	Pound per Tree.
1926–27	62	106	119
1927–28	143·4	119	97·5
1928–29	129	138	197·3
Totals per tree	334·6	363·8	413·8
Average annual yield	111·5	121·3	137·9
Number of trees in experiment ..	13	14	8

NOTE.—The yields represent the average of the yields from three groups of similar trees in each block. These groups are (1) Kalamazoo, (2) large Wiggins trees, (3) intermediate Wiggins trees.

Discussion of Results.

The data presented in Table 2 show that great improvement in yield has resulted on Blocks II and III, which have been treated with the complete and nitrogenous fertilizers respectively. The results in the last three seasons, during which the trees have been in full bearing, show that the average annual increase in yield per tree is 24 lb. on the block with the complete fertilizer and 42 lb. on the block receiving 3 lb. per tree of nitro-

genous fertilizers. It would appear that nitrogenous manures are the most important for peaches on this soil, and that phosphate and potassic fertilizers have had little effect. The use of 3 lb. of nitrogenous fertilizer per tree has given a much higher yield than that obtained from the use of 6 lb. per tree of a complete fertilizer containing only 2 lb. of nitrogenous fertilizers.

The increases in yield on the Mamie Ross block are equivalent to 72 bushels of fruit per acre with the complete fertilizer treatment, and 120 bushels per acre in the case of the treatment with nitrogenous fertilizers. In both instances a handsome profit is shown on the expenditure for manures.

The results obtained on the Mamie Ross block are confirmed by those from the Kalamazoo and Wiggins block. Owing to variation in tree-position, amount of light, and competition from neighbouring trees, undue emphasis must not be placed on the results from the latter block. The yields from the three plots on the Kalamazoo and Wiggins block are, however, in general agreement with those from the Mamie Ross variety, and show the great importance of nitrogenous manures for peaches on the Motueka soil.

Earlier in this paper mention has been made of the prevalence of dieback of peaches in the Motueka district. The experimental blocks have suffered badly in this respect, and heavy pruning has frequently been required to eliminate diseased wood. Up to the present the yield of fruit has been well maintained, but the prospects for the coming season are not nearly as good.

Although fungus disease is invariably associated with dieback, it was thought that inadequate nutrition of the trees might be connected with the severity of its incidence. With a view to securing information on this point, observations have been made of the amount of dieback on the various blocks under manurial treatment, and a further experiment has been conducted to ascertain whether iron sulphate is beneficial in reducing the amount of dieback.

Little difference has been detected in the amount of dieback on the various experimental blocks, indicating that little relationship exists between its incidence and the supply of the common plant-foods. Iron sulphate, despite the fact that it has been applied in four consecutive seasons at the rate of 8 lb. per tree, has not effected any significant improvement in the occurrence of dieback. In view of the common use of iron sulphate in certain orchards at Riwaka, it is of interest to record that the use of iron sulphate was not accompanied by any marked improvement either in vigour of the trees or in yield of fruit. On two plots no increase in yield was obtained, but on a third plot, treated with nitrogenous fertilizers without phosphate and potash, an apparent increase resulted. Averaging the results from the three plots, an annual yield of 133 lb. per tree was obtained where iron sulphate had been used, against 127·5 lb. per tree without iron sulphate. This difference is not significant, and gives little support to the commonly accepted belief that iron sulphate is highly beneficial for fruit-trees on soils of the Motueka district.

Summary.

Manurial experiments have been conducted on several varieties of peaches located on the two chief peach soils of the Nelson district. The

experiments have extended over a period of years, and have demonstrated the importance of manurial treatment for peaches on these soils. On the Motueka soil, which is well supplied with available phosphate and lime, nitrogenous fertilizers used at the rate of 3 lb. per tree have given an average annual increase in yield of 1 bushel per tree. Little benefit is noticeable from the use of phosphates and potash on this soil. On the Stoke soil the use of a complete fertilizer supplying 2 lb. of superphosphate, 1 lb. sulphate of potash, 1 lb. ammonium sulphate, and 2 lb. nitrate of soda per tree has resulted in an increase of approximately ½ bushel of fruit per tree. In both experiments the increase in yield shows a handsome profit on the cost of fertilizers.

The results of the manurial experiments point clearly to the great importance of nitrogenous manures for peach orchards, and indicate that a dressing of at least 3 lb. per tree for orchards in full bearing is required for optimum fruit-production.

In regard to the use of phosphates and potash for the manuring of peaches the position is not so clear. On the fertile sand of Umukuri, which is very well supplied with phosphate, little phosphatic manure should be required. Although the data which have been obtained do not suggest that potassic manures have been very beneficial on the Umukuri sand, yet the supply of available potash in the soil is below normal, and growers would be well advised to use at least 1 lb. of sulphate of potash per tree in manuring.

The Stoke soil is typical of many average soils used for peach-culture throughout New Zealand. Undoubtedly the liberal use of nitrogenous manures at the rate of 3 lb. per tree is essential for the maintenance of high yield. Owing to a more restricted root-range on such soils, it is highly desirable to maintain the humus supply of the soil by ploughing in green crops, and to use both phosphate and potash in the manuring of the trees. A dressing of 2–3 lb. of superphosphate, 1 lb. of sulphate of potash, 1 lb. of ammonium sulphate, and 1 lb. of dried blood per tree is recommended for use in the early part of September. About the middle of November a further top-dressing of 1 lb. per tree of either nitrate of soda or ammonium sulphate should be made.

The use of iron sulphate for peaches in the Umukuri district has not been accompanied by any improvement either in yield of fruit or control of die-back.

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